Pathways Through Earth Resources

A Case Study: Oil

Grades 6–12

Integrated Waste Management Board

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The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.

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Table of Contents

Earth Resources
A Case Study: Oil
Pathways

Earth Resources—A Case Study: Oil engages students in understanding life, earth, and environmental science, while maximizing their scientific thinking processes and developing their strategies for responsible action and community outreach. The curriculum is designed to address four major concepts in natural resource conservation: formation, exploration, and acquisition; processing; everyday use; and proper disposal/ recycling. Through a series of 18 lessons that involve research, discussions, and explorations about oil, and a pupil-selected case study, students come to understand the complexities and interdependence of geological, biological, and environmental concepts as well as economic factors.

Pathways is an effort to align this well-received curriculum to the California Science Content Standards adopted by the California State Board of Education in 1998 and to broaden the use of the curriculum with a variety of students. Each "pathway" maintains the integrity of the original design: opportunities to address the four major concepts of natural resource conservation through active learning experiences for students. AND, each pathway aligns to the California Science Content Standards for a specific grade or course.

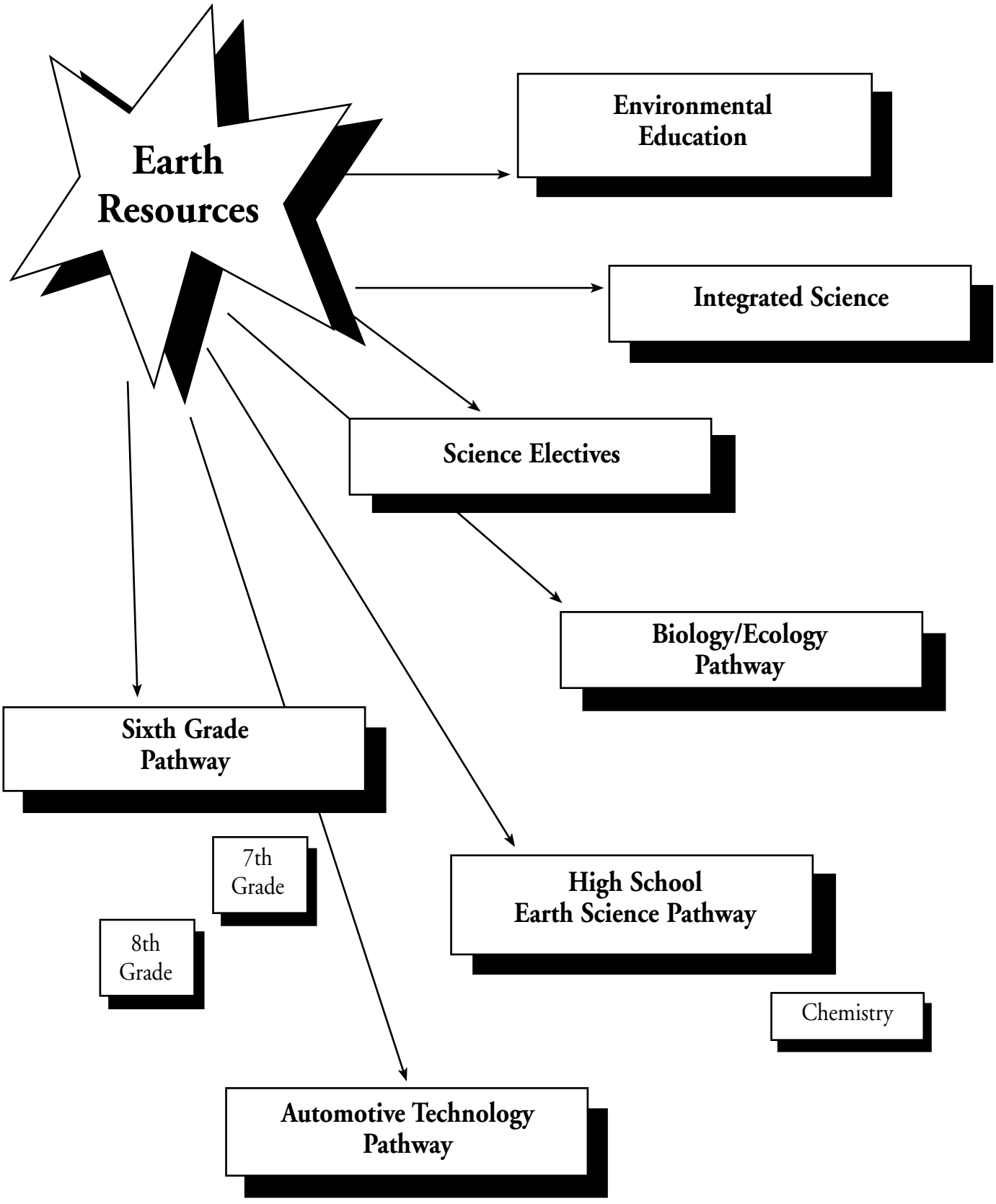
With the addition of Pathways, educators can use Earth Resources in a multitude of classrooms. Use it in its entirety for integrated science classes, environmental education classes, or science electives, or use the following Pathways to target specific grades/courses:

-Sixth Grade (Focus on Earth Science)
-High School Ecology (Biology)
-High School Earth Science
-Automotive Technology

Each "pathway" serves as a guide through the original Earth Resources curriculum. A lesson sequence and a narrative storyline link each lesson to the previous one. Lessons should be used as they were originally designed, unless the lesson has been modified—or a lesson has been added. In either case, directions for the use of these lessons are included in the pathway. A standards match is included at the end of each pathway.

Pathways was developed through a collaboration between the California Integrated Waste Management Board and the K–12 Alliance (CSIN•SPAN•SS&C).

Pathways


Earth Resources
Environmental Education
Integrated Science
Science Electives
Biology/Ecology Pathway
Sixth Grade Pathway
7th Grade
8th Grade
High School Earth Science Pathway
Chemistry
Automotive Technology Pathway

Sixth Grade Pathway

Curriculum Application

The California Science Standards for grade 6 focus on Earth Science and address several topics: plate tectonics, shaping the Earth's surface, heat, energy in the Earth system, ecology, and resources.

A "big idea" that encompasses all of the sixth grade standards is "energy flow affects the Earth's living and physical systems." The following concepts support this idea:

- Heat energy from the core of the Earth can be transferred to the surface and can be transformed into movement that affects surface features.

- The surface of the Earth is a result of internal energy flow (e.g., plate tectonics, mountain building) as well as external energy flow (wind and water movement) which can change the Earth's topography.

- Ecosystems are dependent upon the flow of energy and the cycling of matter between biotic and abiotic factors.

- Humans use energy and material resources. These resources differ in amounts, distribution, usefulness, and the time required for their formation.

The Sixth Grade Earth Resources Pathway provides students with inquiry-based investigations that address the ecology and natural resources. It provides a foundation for understanding the "big ideas" of how Earth resources are formed over time, and how humans use and care for these resources.

Students explore the use and disposal of oil and consequences of not disposing of it properly. Throughout the unit, students are provided with the skills and opportunities to develop strategies for responsible action and community outreach.

Lesson Sequence in the Sixth Grade Pathway

Section 1

Lesson 1 As the World Turns: *The Earth Resources*

Lesson 2 Meet Crude Oil: *An Earth Resource Case Study*

Lesson 3 Crude Oil Is Trapped: *Geologic Processes for Oil Formation*

Lesson 4 Getting Crude Oil: *Oil Extraction*

Lesson 5 Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

Section 2

Lesson 6m *Lesson Modification*
Slipping and Sliding With Oil: *The Lubricating Properties of Oil*

Lesson 10m *Lesson Modification*
Oil Keeps Clean and Changes: *The Role of Oil Filters in an Engine*

Section 3

Lesson 11 What To Do With Used Oil? *Surface Water*

Lesson 12 What To Do With Used Oil? *The Backyard*

Lesson 13 What To Do With Used Oil? *The Trash Can*

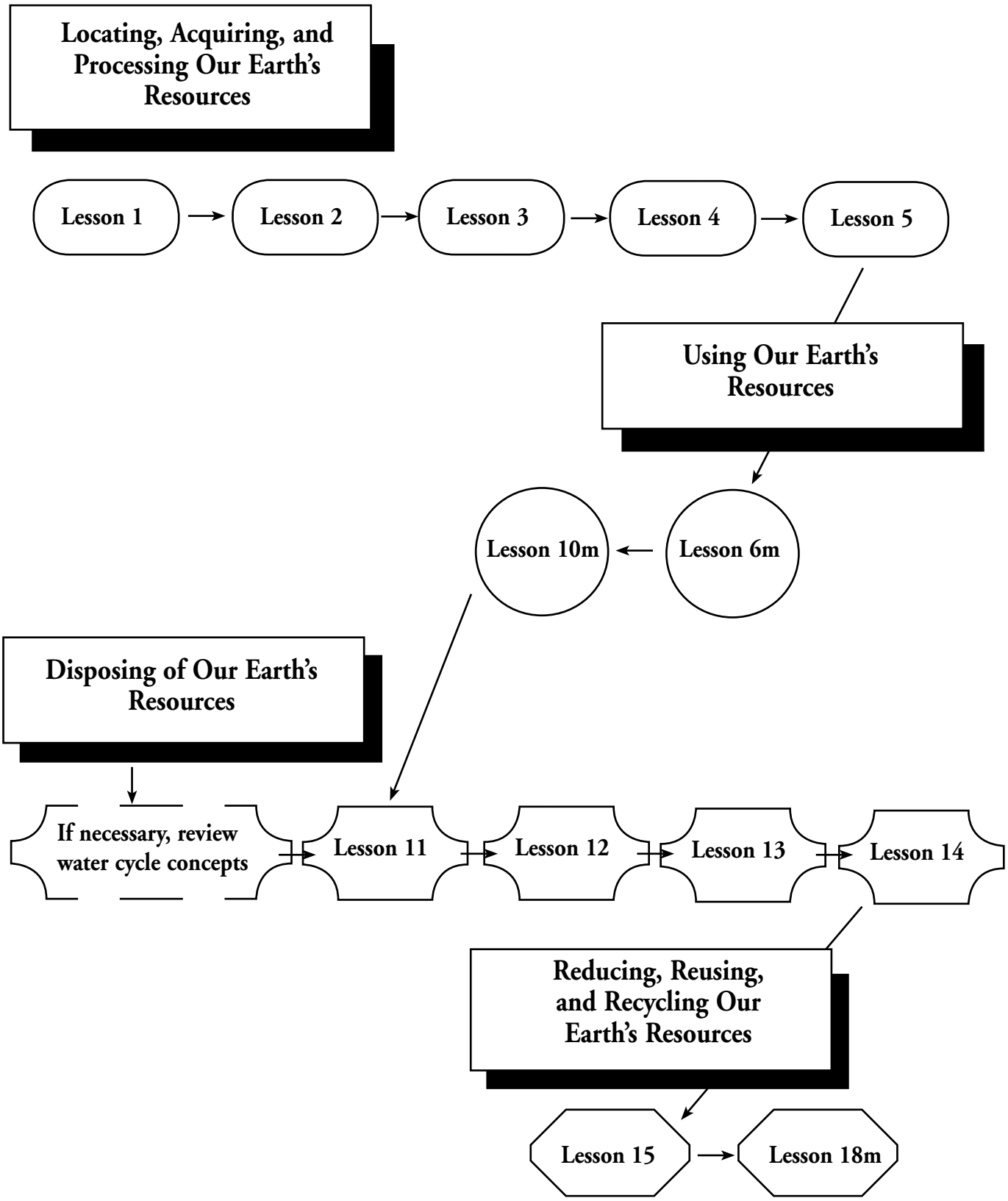
Lesson 14 Why Should We Care About Used Oil? *How Used Oil Can Affect the Environment*

Section 4

Lesson 15 What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

Lesson 18m *Lesson Modification*
Earth Resources Case Study: *Sharing Solutions*

Sixth Grade Pathway Schematic



Storyline Narrative
Sixth Grade Pathway

In the Sixth Grade Earth Science Pathway, students use concepts from Earth science to identify Earth's resources and explore the acquisition and impact of the use of these resources in the Earth. Students apply their knowledge through researching and presenting their own Student Case Study (see page 63)
This pathway follows the four major sections in the Earth's Resources curriculum:

- Section 1: Lessons 1–5 focus on the formation, exploration, acquisition, and processing of crude oil.
- Section 2: Lessons 6 and 10 focus on use of oil by humans.
- Section 3: Lessons 11–14 focus on the environmental impact.
- Section 4: Lessons 15 and 18 focus on human responsibility toward the environment.

Section 1

Earth Resources—A Case Study: Oil follows the natural resource oil from its formation deep in the Earth to recycling the products that humans make from it. Lesson 1, **As the World Turns,** introduces the idea that the Earth's resources are formed over time, that humans use these resources, and that resources can be classified as renewable or nonrenewable.

Meet Crude Oil, Lesson 2, allows students to explore crude oil, its origins, and the stages of its formation. As part of the lesson, students discover that crude oil is a nonrenewable resource with both physical and chemical properties that can change over time. In Lesson 3, **Crude Oil is Trapped**, students investigate the geological processes that have contributed to the accumulation of crude oil. By manipulating materials in a squeeze box, students are able to simulate a series of geological steps that allow oil to be trapped.

In Lesson 4, **Getting Crude Oil,** and Lesson 5, **Crude Oil Becomes Refined,** students investigate the process of oil extraction and process of refinement through distillation. In each lesson, students simulate the processes involved in extraction and distillation. Students come to recognize that one of the products from refined crude oil is oil used for lubricating car engines. Through questions and discussions, students begin to understand the economic and environmental issues surrounding the acquisition of natural resources.

Section 2

In Section 2 of this unit students focus on the human use of oil. Lesson 6m, **Slipping and Sliding With Oil,** explores the properties of oil that make it useful to humans and then discusses the effects of oil on a car engine. In modified Lesson 10, **Oil Keeps Clean and Changes**, students reflect on the role of oil in the engine (lubrication, cleaning), and the need for an oil filter. Students investigate the differences between new and used oil and the action of filters. Students create an oil filter and separate the oil mixture by filtering for particle size.

Section 3

Ecosystems of the Earth are interdependent and a change in one system may have far-reaching effects on others. Lessons 11, 12, and 13 are dependent upon students having a fundamental understanding of the hydrologic cycle. *If students have a limited understanding of the water cycle, review the major concepts before teaching Section 3.*

In Lesson 11, **What to do With Oil?** ***Surface Water,*** students continue to build an understanding of how humans affect ecosystems by analyzing the environmental impact of contaminants on plant and animal life. In Lesson 12, **What to do With Oil?** ***The Backyard,*** students analyze the effect of dumping oil in the backyard. Lesson 13, **What to do With Used Oil?** ***The Trash Can,*** enables students to identify how used motor oil travels through a model of a landfill and then analyze the environmental impact.

Lesson 14, **Why Should We Care About Used Oil?** asks students to evaluate the impact of used oil in the ecosystem. In this lesson students trace the path of a contaminant through a food pyramid and explore the idea that concentrations of heavy metals, such as those found in motor oil, increase in a food pyramid. Students analyze how a change in one population can affect another population.

Section 4

In Section 4, students identify opportunities for humans to maintain a sustainable system through careful management of the Earth's resources. Lesson 15, **What Difference Can I Make?** explores the recycling of used oil and other household hazardous waste as a management process. In Lesson 18m, **Earth Resources Case Study:** ***Sharing Solutions,*** students complete the unit by sharing their Public Information Announcements and Earth Resources Projects, and by completing the Earth Resources Chart for oil. Students reflect on what they learned and discuss what actions they can personally take to properly manage and conserve the Earth's resources.

Lesson Modifications
(Lessons 6, 10, and 18)

Lesson 6: Slipping and Sliding With Oil

• Home Study

Delete this assignment

Lesson 10: Oil Keeps Clean and Changes

• Prethink

Modify the Prethink by adding the following prompts:

What is the basic function of oil in an engine?
Most students will probably cite its lubricating function.

Burn the candle (from Lesson 8) and relate to the burning of gasoline in the engine.

How might oil help with the "soot" released by the burning gasoline?
Oil picks up the soot.

What else do you think oil might do?
Some might suggest its additives include detergents, or that it picks up and removes tiny abrasive fragments of metal that occur as a product of wear inside the engine.

What part of the engine is designed to remove the particles from the oil?
The oil filter removes the particles from the oil.

Continue with the prompts as stated on page 240.

Lesson 18: Sharing Solutions

• Prethink

Modify the Prethink by deleting the following prompt:

Let's share your "Home Study—New or Re-Refined Oil?"

Sixth Grade (Focus on Earth Science)
Standards Alignment

Lessons 1, 2, 3, 4, 5, 6m, 10m, 11, 12, 13, 14, 15, 18m

Plate Tectonics and Earth's Structure	**Lesson Examples**
1. Plate tectonics explains important features of the Earth's surface and major geologic events. As the basis for understanding this concept:	
a. Students know evidence of plate tectonics is derived from the the fit of the continents, the location of earthquakes, volcanoes, and midocean ridges, and the distribution of fossils, rock types, and ancient climatic zones provide evidence for plate tectonics.	Lessons 2, 3
b. Students know the solid Earth is layered composed of several layers: with a cold, brittle lithosphere; a hot convecting mantle; and a dense metallic core.	Lesson 3
c. Students know lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.	Lesson 3
d. Students know earthquakes are sudden motions along breaks in the crust called faults, and volcanoes/fissures are locations where magma reaches the surface.	Lesson 3
e. Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.	Lesson 3
Shaping the Earth's Surface	**Lesson Examples**
2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment. As the basis for understanding this concept:	Lesson 3
a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.	Lesson 11
b. Students know rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.	Lessons 3, 5, 11
c. Students know beaches are dynamic systems in which sand is supplied by rivers and moved along the coast by wave action.	
d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.	Lessons 2, 3
Heat (Thermal Energy) (Physical Science)	**Lesson Examples**
3. Heat moves in a predictable flow from warmer objects to cooler objects until all objects are at the same temperature. As a basis for understanding this concept:	
a. Students know energy can be carried from one place to another by heat flow, or by waves including water waves, light and sound, or by moving objects.	Lesson 4
Energy in the Earth System	**Lesson Examples**
4. Many phenomena on the Earth's surface are affected by the transfer of energy through radiation and convection currents. As a basis for understanding this concept:	
a. Students know the sun is the major source of energy for phenomena on the Earth's surface; it powerings winds, ocean currents, and the water cycle.	Lesson 11
Ecology (Life Science)	**Lesson Examples**
5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:	Lesson 14
a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs.	Lesson 14
b. Students know over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.	Lesson 14
c. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.	Lesson 14
Resources	**Lesson Examples**
6. Sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation. As a basis for understanding this concept:	
a. Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.	Lessons 1, 2, 3, 4, 5, 6, 10
b. Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and classify them as renewable or nonrenewable.	All lessons; Student Case Study

c. Students know natural origin of the materials used to make common objects.	Lessons 1, 2, 3, 4, 5, Student Case Study
Investigation and Experimentation	**Lesson Examples**
7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:	
a. Develop a hypothesis.	Lessons 10, 11, 12, 13, 18, Student Case Study*
b. Select and use appropriate tools and technology (including calculators and computers) to perform tests, collect data, and display data.	Lessons 1, 5, 8, 10, 11, 12, 13, Student Case Study
c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.	Lessons 4, 5, 8, 12, Student Case Study
d. Communicate the steps and results from an investigation in written reports and verbal presentations.	Lessons 1, 2, 3, 4, 5, 6, 8 , 9, 10, 11, 12, 13, 14, 15, 18, Student Case Study
e. Recognize whether evidence is consistent with a proposed explanation.	Lesson 14, Student Case Study, Service Learning Project
f. Read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.	Student Case Study*
g. Interpret events by sequence and time from natural phenomena (e.g., relative ages of rocks and intrusions). 14, Student Case	Lessons 2, 3, 11, 12,13, Study*
h. ~~Identify changes in natural phenomena over time without manipulating the~~ phenomena (e.g., a tree limb, a grove of trees, a stream, and a hill slope).	Lesson 3, Student Case Study*

* has potential to meet the standard

High School
Biology/Ecology Pathway

Curriculum Application

Ecology is an integral part of the biology classroom and affords students opportunities to take personal responsibility for their actions concerning the environment. Ecology courses emphasize several concepts including:

- The interaction of biotic and abiotic components of an ecosystem (e.g., ecological pyramids, biogeochemical cycles, energy flow and changes).
- Biodiversity is vital to an ecosystem.
- The dynamics of population growth impacts the environment.
- Humans have a responsibility towards the environment.

Earth's Resources aligns with elements of the first two concepts and strongly emphasizes the last. The ecology pathway provides opportunities for students to understand the following concepts:

- The stability of producers and decomposers is a vital part of an ecosystem.

- Each link in a food pyramid stores energy in newly made structures, but some energy is lost as heat, which can be represented as an energy pyramid.

- Alteration of a habitat impacts the stability of the ecosystem; biodiversity is affected by alterations of habitats.

- Human action impacts the environment; students' personal choice for the disposal of Earth's resources affects the environment.

The Earth Resources curriculum introduces and explains these ideas in an activity-based format and enables students to apply these concepts by doing research on natural resources or by becoming involved in a service learning project.

Lesson Sequence in the High School Biology/Ecology Pathway

Section 1

Lesson 1: As the World Turns: *The Earth's Resources*

Lesson 2: Meet Crude Oil: *An Earth Resource Case Study*

Lesson 3: Crude Oil Is Trapped: *Geologic Processes for Oil Formation*

Lesson 4: *Lesson Modification*
Getting Crude Oil: *Oil Extraction*

Lesson 5: *Lesson Modification*
Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

Section 2

Lesson 8: *Lesson Modification*
Oil, the Pickup Artist: *The Cleaning Function of Lubricating Oil*

Section 3

Lesson 11: What to Do With Used Oil? *Surface Water*

Lesson 12: What to Do With Used Oil? *The Backyard*

Lesson 13: What to Do With Used Motor Oil? *The Trash Can*

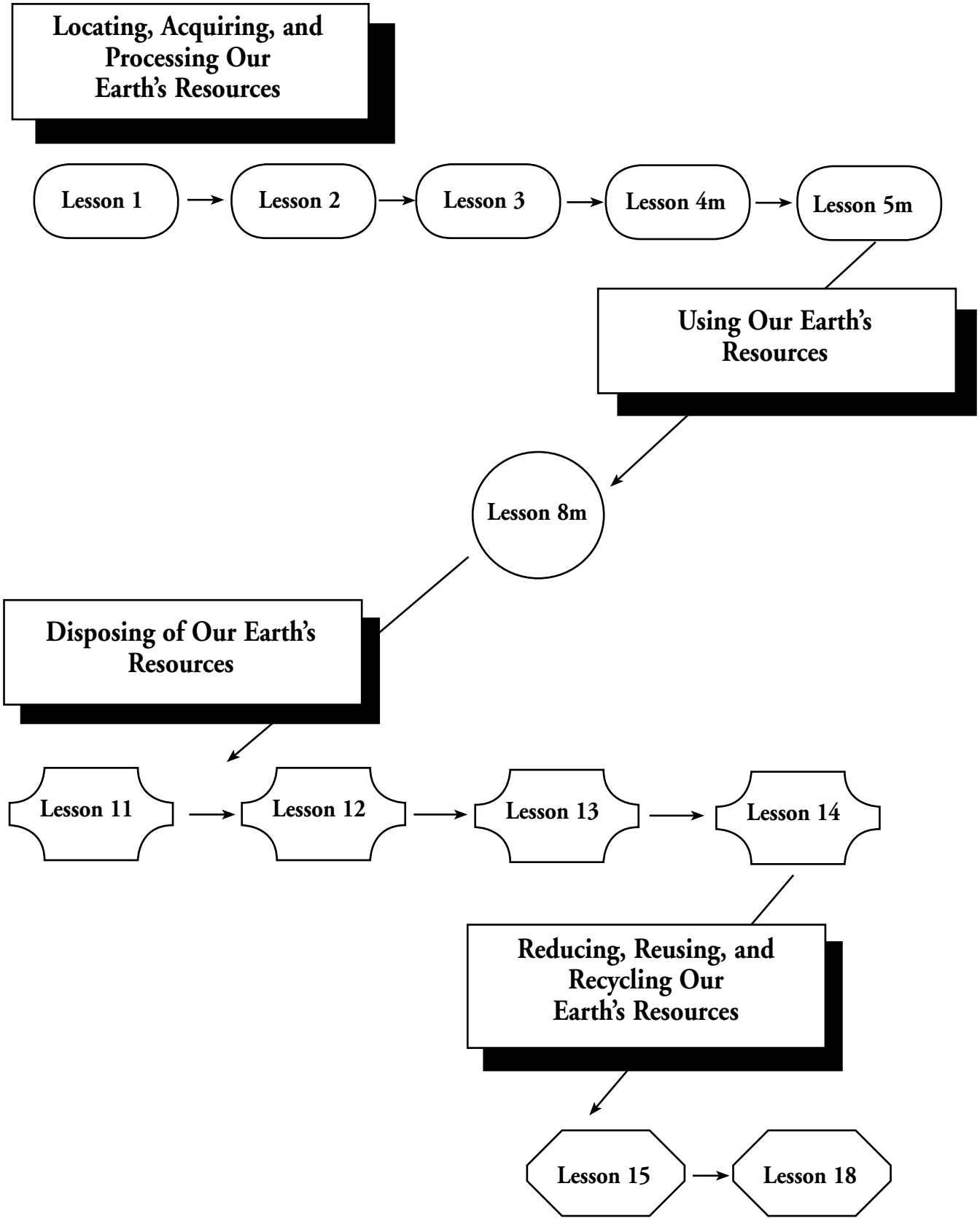
Lesson 14: Why Should We Care About Used Oil? *How Used Oil Can Affect the Environment*

Section 4

Lesson 15: What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

Lesson 18: Earth Resources Case Study: *Sharing Solutions*

High School Biology/Ecology Pathway Schematic



Storyline Narrative High School
Biology/Ecology Pathway

In the Ecology Pathway, students identify Earth's resources, explore the processes for obtaining these resources, and understand the impact on the environment of the acquisition and disposal of these resources. Students apply their knowledge through researching and presenting their own Student Case Study (see page 63).

This pathway follows the four major sections in the Earth's Resources curriculum:

- Section 1: Lessons 1, 2, 3, modified 4, and modified 5, focusing on the formation, exploration, acquisition, and processing of crude oil.
- Section 2: Modified Lesson 8 focuses on use of oil by humans.
- Section 3: Lessons 11–14 focus on the environmental impact.
- Section 4: Lessons 15 and 18 focus on human responsibility toward the environment.

The Earth's Resources curriculum focuses on the "life cycle" of oil. Students in ecology classes need additional experience with the impact of other resources on the environment. The Student Case Study (page 63) provides this opportunity. In addition, the Service Learning Project (page 437) enables students to bring these issues to their community.

Section 1

Human populations, in order to maintain and improve their existence, use natural resources. In Lesson 1: **As the World Turns,** students identify Earth resources used to manufacture commonly used products and identify whether the resources are renewable or nonrenewable.

Focusing on oil as an object from the Earth Resources Chart, students in Lesson 2: **Meet Crude Oil** explore how crude oil is formed over millions of years and determine that oil is a nonrenewable resource. For the ecology pathway, emphasize the role that marine plankton, environmental conditions, and carbon play on the formation of the crude oil.

Earth's natural processes, over time, physically and chemically change the Earth's materials. The processes of deposition and tectonics are explored in Lesson 3: **Crude Oil is Trapped**. Students investigate how these processes interact and infer the location of crude oil below the Earth's surface. For the ecology pathway, emphasize how these Earth's processes are changing the environment.

Using both modified Lesson 4: **Getting Crude Oil** and modified Lesson 5: **Crude Oil becomes Refined** as demonstrations, students discuss the process of extracting crude oil and refining it for use. Students identify the economic and environmental issues relating to these processes and recognize that one of the products from refined crude oil is oil used for lubricating car engines.

At the conclusion of this section, introduce the **Student Case Study** in which students choose an Earth

resource to investigate. Students will research how their resource is extracted, processed, used, and disposed of while emphasizing the environmental impact of each step in the life cycle of the resource.

Section 2

As resources are used, changes occur in them that may make the resource unusable. In the modified Lesson 8: **Oil, The Pickup Artist**, students identify gasoline as a petroleum product and discuss how burning gasoline produces products that can damage an engine. Students investigate the cleaning properties of lubricating oil and how oil affects an engine's performance and efficiency. They identify changes in the oil itself.

Section 3

Oil eventually becomes too dirty to be cleaned with the oil filter and it must be changed to maintain the engine's efficiency. Disposal of oil impacts the environment and can create negative changes in ecosystems. Lessons 11–14 provide opportunities for students to investigate this impact.

In Lesson 11: **What to do with Used Oil:** ***Surface Water,*** students conduct a simulation to determine the effects of disposing used oil in waterways. They learn that this common—but hazardous and illegal—method of used motor oil disposal contaminates the water and affects plants and animals by altering the habitat. This alteration can affect biodiversity and can have a negative impact on the food chain.

Why is dumping oil onto the ground illegal and hazardous? Oil products that are dumped onto the ground end up in the watershed and in surface waters. Lesson 12: **What To Do With Used Oil:** ***The Backyard*** illustrates that groundwater contamination can pollute surface water and drinking water supplies.

A landfill is actually a habitat unto itself, with a complex community of microbes and other organisms. In Lesson 13: **What To Do With Used Oil:** ***The Trash Can,*** students build and monitor a landfill model to show the impact of improper disposal in landfills.

Lesson 14: **Why Should We Care About Used Oil?** illustrates how a small amount of a toxin can affect the food chain/web and upset the dynamic balance within ecosystems.

Section 4

Human activities should aim at maintaining a sustainable system through careful management of Earth's resources. Individuals can make choices that conserve natural resources. In Lesson 15: **What Difference Can I Make?** students explore the recycling of used oil and other household hazardous waste, realizing that each individual's actions can make a difference. In Lesson 18: **Earth Resources Case Study,** the storyline comes full circle with the students presenting their Earth Resource Project to the class connecting everything they have learned about extraction, processing, use, and disposal of Earth resources.

Lesson Modification
Lesson 4—Getting Crude Oil: *Oil Extraction*

•Prethink
Modify the Prethink as follows:

Use first prompt as stated (best locations to drill). Delete the rest of the prompts and insert:

How do you think oil is extracted from the ground? Have any of you seen oil wells? Oil pumps?
Oil is pumped out of the ground using an oil derrick.

Display the Oil Derrick and Oil Well Overhead.
Use background information to briefly discuss how the well works.

Show the demonstration pump and ask how this pump is similar to the well.
Answers will vary; focus on pumping action, level of pump to the oil source; amount of oil extracted.

• Student Investigation
Replace Student Investigation with Classroom Demonstration

Use student directions for oil/pebble method and cold-water method. Ask several students to help in the demonstration. Record the data in the data table for the oil/pebbles and cold water design.

• Action Processing
Use the first two prompts for Action Processing, then insert:

Brainstorm some of the environmental issues involved in pumping oil from the ground.
Answers will vary based on student experience; possible answers include—oil leaks/spills into the environment, disruption of the groundwater, costly, disruption of habitats.

Complete the Earth Resources Chart for oil using the prompts on page 117.

Lesson Modification
Lesson 5—Crude Oil Becomes Refined

• Prethink
Modify the Prethink as follows. Delete prompts and insert:

Once the crude oil is out of the ground, how do you think it is processed into a form that we can use?
Answers may vary.

How can we separate a mixture into its different parts?
Elicit ideas from the class that take into account the properties of the substances: size, solubility, evaporation rate.

How can we separate a mixture of two liquids?
On the board, list the properties of water and isopropanol as indicated on the chart on page 134.

How can we separate the alcohol and water? Show the distillation demonstration.

• Student Investigation
Replace Student Investigation with Classroom Demonstration

Use student directions for the fractional distillation. Ask several students to help in the demonstration. Record the data in the data table and use the analysis question to process the data.

• Action Processing
Use the first three prompts for Action Processing, then insert:

Since distillation separates one part, or fraction, of the mixture at a time, it is often referred to as fractional distillation.

Display Overhead——Fractional Distillation of Crude Oil.
The petroleum industry uses this process to separate the components of crude oil into useable products.

What are some of the environmental impacts associated with fractional distillation?
See page 135 for text.

Complete the Earth's Resources Chart.

Lesson Modification
Lesson 8—Oil, the Pickup Artist

• Prethink
Modify the Prethink as follows. Replace the first three prompts with:

What is the basic function of oil in an engine?
Most students will probably cite its lubricating function.

What else do you think oil might do?
Some might suggest its additives include detergents, or that it picks up and removes tiny abrasive fragments of metal that occur as a product of wear inside the engine.

Continue with the prompts.

• Student Investigation: Use Student Investigation as presented.

• Action Processing
Delete Action Processing prompts and insert these instead:

What is one of the functions of motor oil in the engine that we discovered in this activity?
Oil cleans the engine, removing carbon particles and tiny fragments of metal.

Why is oil better than water at removing particles from the engine?
Metal particles remain suspended longer in oil, allowing them to be filtered.

What part of the engine is designed to remove the particles from oil?
The oil filter removes the particles from the oil.

Why should the oil and oil filter be changed at regular intervals?
Because carbon, bits of metal, and other contaminants make the oil dirty and the filter can only "hold" so much. Both are changed to prevent "clogging."

What are some other functions of motor oil in the car?
Oil lubricates the engine and helps to keep the engine cool.

What are some of the environmental impacts of using motor oil?
Burning oil causes particulate air pollution. Leaking oil becomes nonpoint source pollution and gets into watersheds. "Dirty" oil must be disposed of in the environment.

Complete the Earth Resources Chart **(see page 205).**

High School Biology/Ecology

Standards Alignment

Lessons 1, 2, 3, 4m, 5m, 8m, 11, 12, 13, 14, 15, 18

Physics

Heat and Thermodynamics	Lesson Examples
3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:	Lesson 8
b. Students know that the work done by heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation energy.	

Chemistry

Chemical Bonds	Lesson Examples
2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:	
b. Students know chemical bonds between atoms in molecules such as H2, CH4, NH3 , H2CCH2 , N2, Cl2, and many large biological molecules are covalent.	Lesson 5
Solutions	**Lesson Examples**
6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:	Lesson 8
a. Students know the definitions of solute and solvent.	Lesson 8
c. Students know temperature, pressure, and surface area affect the dissolving process.	Lesson 5
d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	Lesson 11
Chemical Thermodynamics	**Lesson Examples**
7. Energy is exchanged or transformed in all chemical and physical changes of matter. As a basis for understanding this concept:	
b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.	Lesson 8

Biology/Life Sciences

Ecology	Lesson Examples
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:	Lessons 2, 11, 12, 13, 14, 18
a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.	Lessons 2, 11, 12, 13, 14, 18
b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.	Lessons 2, 4, 11, 12, 13, 14, 15, 18
d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.	Lessons 3, 12, 13, 14, 18
e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.	Lessons 11, 12, 14, 18
f. Students know at each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.	Lessons 14, 18

Earth Sciences

Earth's Place in the Universe	Lesson Examples
1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:	
c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.	Lesson 2
Dynamic Earth Processes	**Lesson Examples**
3. Plate tectonics operating over geologic time hasve changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:	Lessons 2, 3
a. Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.	Lessons 2, 3
Biogeochemical Cycles	**Lesson Examples**
7. Each element on Earth moves among reservoirs, which exist in the solid Earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept	
a. Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.	Lesson 14
b. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.	Lessons 2, 3
c. Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.	Lessons 2, 3
California Geology	**Lesson Examples**
9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:	
a. Students know the resources of major economic importance in California and their relation to California's geology.	Lessons 1, 2, 3, 4, 5
c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.	Lessons 11, 12

Investigation and Experimentation

Investigation and Experimentation	Lesson Examples
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:	Student Case Study, Public Information Announcement, Service Learning Project
a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.	Lessons 1, 3, 5, 8, 10, 11, 12, 13, 14, Student Case Study, Public Information Announcement, Service Learning Project
d. Formulate explanations by using logic and evidence.	Lessons 3, 4 ,5, 6, 8, 11, 12, 13, 14, 15, Student Case Study, Service Learning Project.
e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.	Student Case Study*
g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.	Lessons 2, 3, 4, 11, 12, 13, 14, Student Case Study*, Service Learning Project*
h. Read and interpret topographic and geologic maps.	Student Case Study,* Service Learning Project*

i.	Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).	Lessons 1, 2, 3, 11, 12, 13, 14, Student Case Study*
j.	Recognize the issues of statistical variability and the need for controlled tests.	Lessons 8, Student Case Study*
k.	Recognize the cumulative nature of scientific evidence.	Lessons 11, 12, 13, 14, 15, Student Case Study, Service Learning Project
l.	Analyze situations and solve problems that require combining and applying concepts from more than one area of science.	Lessons 1, 2, 3, 4, 5, 8, 11, 12, 13, 14, 15, 18, Student Case Study, Service Learning Project
m.	Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.	Lessons 11, 12, 13, 14, 15, 18, Student Case Study, Public Service Learning Information Announcement, Project

*has potential to meet the standard

High School Earth Science Pathway

Curriculum Application

A typical high school Earth Science course is organized into four content areas:

- Astronomy (gaseous space)
- Meteorology (Earth's gaseous layer)
- Oceanography (Earth's liquid layer)
- Geology (Earth's solid layer)

While each of these areas is grounded in specific concepts, these areas are also connected conceptually by many crosscutting themes. Two such themes are ecology—that intersection of the living and non-living environment—and natural resources—those resources that occur in the environment. The Earth Resources curriculum provides engaging investigations into both of these areas and reinforces concepts in Plate Tectonics. Furthermore, The Earth Resources curriculum directly addresses fossil fuels and water—two very important resources to California's economy and environment.

Lesson Sequence in the High School Earth Science Pathway

Section 1

Lesson 1 As the World Turns: *The Earth's Resources*

Lesson 2 Meet Crude Oil: *An Earth Resource Case Study*

Lesson 3 Crude Oil is Trapped: *Geologic Processes for Oil Formation*

Lesson 4 Getting Crude Oil: *Oil Extraction*

Lesson 5 Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

Section 2

Lesson 6i *Lesson Insert*
Use of Petroleum Products

Section 3

Lesson 11 What to Do with Used Oil? *Surface Water*

Lesson 12 What to Do with Used Oil? *The Backyard*

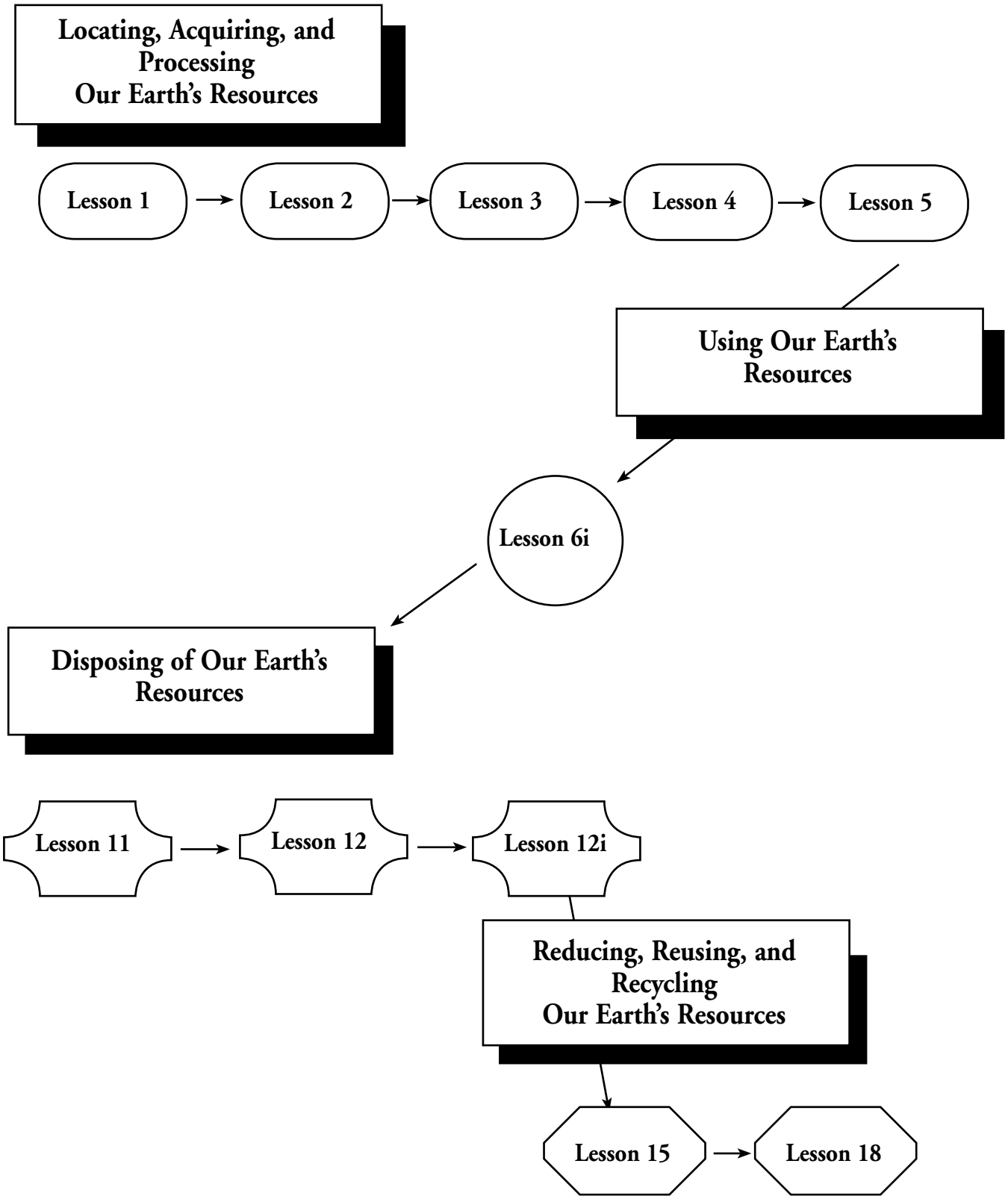
Lesson 12i What to Do with Used Oil? *Disposal and the Environment*

Section 4

Lesson 15: What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

Lesson 18: Earth Resources Case Study: *Sharing Solutions*

High School Earth Science Pathway Schematic



Storyline Narrative High School
Earth Science Pathway

In the High School Earth Science Pathway, students use concepts from Earth Science to identify Earth's resources and explore the acquisition and impact of the use of these resources in the Earth. Students apply their knowledge through researching and presenting their own Student Case Study (see page 63).

This pathway follows the four major sections in the Earth's Resources curriculum:

- Section 1: Lessons 1–5 focus on the formation, exploration, acquisition, and processing of crude oil.
- Section 2: Insert Lesson 6i focuses on use of oil by humans.
- Section 3: Lessons 11, 12, and 12i focus on the environmental impact.
- Section 4: Lessons 15 and 18 focus on human responsibility toward the environment.

Section 1

In Lesson 1, **As the World Turns**, students explore their prior knowledge about how humans use Earth resources to maintain and improve their existence. They identify Earth resources used to manufacture items and identify whether the resources are renewable or nonrenewable. They also explore the positive and negative impacts of processing resources into useful materials. Students then begin the process of a case study that will parallel the work done in class with oil.

Oil is an important and nonrenewable Earth resource. In Lesson 2, **Meet Crude Oil,** students use their prior knowledge of fossil fuel formation to develop and describe the stages of crude oil formation. By analyzing the rate of petroleum consumption, students begin to understand the need to manage resources.

Tectonic forces cause the Earth's structure to be dynamic, creating new geologic formations. In Lesson 3, **Crude Oil is Trapped,** students investigate how these types of geological processes have contributed to the accumulation of crude oil.

In order to use this resource, the crude oil must be extracted from the Earth. Lesson 4, **Getting Crude Oil,** provides students with an opportunity to explore the issues surrounding the acquisition of natural resources and the difficulties of crude oil extraction.

Once extracted, crude oil needs to be refined. In Lesson 5, **Crude Oil Becomes Refined,** students investigate the separation of liquid mixtures by distillation and relate this process to the refining of crude oil.

Section 2

The human use of oil and gasoline is explored in Lesson 6i, **Use of Petroleum Products.**

Section 3

Disposal of oil impacts the environment and can create negative changes in ecosystems. Lessons 11–12i provide opportunities for students to investigate various disposal methods and their impact on the environment.

In Lesson 11, **What to Do with Used Oil:** ***Surface Water,*** students investigate the advantages and disadvantages of a common—but hazardous and illegal—method of used motor oil disposal. Students determine that disposing of used oil in waterways contaminates the water and can impact plants and wildlife.

In Lesson 12, **What to Do with Used Oil:** ***The Backyard,*** students analyze the environmental impact of dumping oil in the backyard. Through an investigation, they determine that a contaminant dumped into a model of a backyard leaches into the groundwater system.

Lesson 12i, **What to Do with Used Oil:** ***Disposal and the Environment,*** helps students understand that disposal of toxic chemicals in landfills creates negative effects on ecosystems.

Section 4

Human activities should aim at maintaining a sustainable system through careful management of Earth's resources. In Lesson 15, **What Difference Can I Make?** students identify opportunities to recycle used oil and other household hazardous waste in their community. They discuss the issues involved in the operation of collection centers that accept used oil and filters from the public.

In Lesson 18: **Earth Resources Case Study,** the storyline comes full circle with the students presenting their Earth Resource Project to the class connecting everything they have learned about extraction, processing, use, and disposal of Earth resources.

Lesson Insert
Lesson 6i
Use of Petroleum Products

Lesson Concepts:

The physical and chemical properties of petroleum products enable them to be used for a variety of purposes.
With use over time, oil needs to be filtered and replaced.

Suggested Time
30 minutes

• Prethink
Modify the Prethink as follows. Replace prompts for Lesson 6 and insert:

What is the basic function of oil in an engine?
Most students will probably cite its lubricating function.

Brainstorm some of the properties of lubricating oil.
Slippery, thick, prevents friction.

• Student Investigation
Select several students to do the investigation as a demonstration. Discuss which substance acted as the best lubricant and how lubricants might improve the performance of an automobile engine (e.g., reduce friction).

• Action Processing
Insert these prompts from Lesson 8 for student discussion:

What happens when substances are burned?
Answers will vary.

Light a candle and allow it to burn. Hold a glass plate above the flame until water condenses and soot forms.

What products are formed?
Soot—carbon particles; gases are given off; light and heat are also given off. All of these products are produced when a chemical change occurs.

How is burning a candle like burning gasoline in an engine?
The products of the burning are the same. The soot remains in the engine chambers.

What would happen if these deposits were not removed?
The engine would become "clogged."

What circulates through the engine that might remove the contaminants?
Oil.

What part of the engine is designed to remove the particles from the oil?
The oil filter removes the particles from the oil.

Why should the oil and oil filter be changed at regular intervals?
Because carbon, bits of metal, and other contaminants make the oil dirty and the filter can only "hold" so much. Both are changed to prevent "clogging."

What are some of the environmental impacts of using motor oil?
Burning oil causes particulate air pollution. Leaking oil becomes nonpoint source pollution and gets into watersheds. "Dirty" oil must be disposed of in the environment.

Complete the Earth Resources Chart. **(See page 205.)**

Lesson Insert
Lesson 12i
What to Do with Used Oil: Disposal and the Environment

Lesson Concept:

A change in one system has far-reaching effects on other systems.

In Lesson 12, students discovered that dumping contaminants in the backyard could leach into the groundwater system. This lesson gives students an opportunity to discuss and think about the impact this leaching can have on an ecosystem. Upon completion of this lesson, students will move into Lesson 15 where they identify ways of using "used oil."

Suggested Time
30 minutes

• Prethink
Questions for Student Discussion

What types of toxic waste, other than used oil, might be generated from households?
Paint, cleaning fluid, chemicals.

What happens when a landfill is used for disposal?

• Student Investigation

Show the video, *Kids Talking Trash,* from Lesson 13.

• Action Processing

What types of precautions would you implement if you were in charge of keeping landfills safe for the environment?
Location, types of materials disposed of in the landfill, a system to deal with the smell, a system to prevent leaking.

What are some of the environmental impacts associated with chemicals leaching into surrounding soils?
Contamination of the waterways and soil, and possible entry into the food chain.
**See Lesson 14 to expand the concept of contaminating the food chain.*

• Display overhead—Action Processing Scenario from Lesson 13 (page 334) and discuss student responses.

High School Earth Science

Standards Alignment

Lessons 1, 2, 3, 4, 5, 6i, 11, 12, 12i, 15, 18

Chemistry

Chemical Bonds	Lesson Examples
2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:	
b. Students know chemical bonds between atoms in molecules such as H2, CH4, NH3, H2CCH2, N2, Cl2, and many large biological molecules are covalent.	Lesson 5
Solutions	**Lesson Examples**
6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:	
c. Students know temperature, pressure, and surface area affect the dissolving process.	Lesson 5
d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	Lesson 11

Biology/Life Sciences

Ecology	Lesson Examples
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:	Lessons 2, 11, 12, 18
a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.	Lessons 2, 11, 12, 18
b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.	Lessons 2, 4, 11, 12, 15, 18
d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.	Lessons 12, 18
e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.	Lessons 11, 12, 18
f. Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.	Lesson 18

Earth Sciences

Earth's Place in the Universe	Lesson Examples
1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:	
c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.	Lesson 2
Dynamic Earth Processes	**Lesson Examples**
3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. As a basis for understanding this concept:	Lessons 2, 3
a. Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.	Lessons 2, 3
Biogeochemical Cycles	**Lesson Examples**
7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept:	
b. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.	Lessons 2, 3
c. Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.	Lessons 2, 3

California Geology	Lesson Examples
9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:	
a. Students know the resources of major economic importance in California and their relation to California's geology.	Lessons 1, 2, 3, 4, 5
c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.	Lessons 11, 12

Investigation and Experimentation

Investigation and Experimentation	Lesson Examples
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:	Student Case Study, Public Information Announcement, Service Learning Project
a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.	Lessons 1, 3, 5, 11,12, Student Case Study, Public Information Announcement, Service Learning Project
d. Formulate explanations by using logic and evidence.	Lessons 3, 4, 5, 11, 12, 15, Student Case Study, Service Learning Project
e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.	Student Case Study*
g. Recognize the usefulness and limitations of models and theories as scientific representations of reality. Student Case Study,* Learning	Lessons 2, 3, 4, 11,12, Service Project*
h. Read and interpret topographic and geologic maps.	Student Case Study,* Service Learning Project*
i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).	Lessons 1, 2, 3, 11,12, Student Case Study*
j. Recognize the issues of statistical variability and the need for controlled tests.	Student Case Study*
k. Recognize the cumulative nature of scientific evidence.	Lessons 11, 12, 15, Student Case Study, Service Learning Project
l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.	Lessons 1, 2, 3, 4, 5, 11, 12, 15, 18, Student Case Study, Service Learning Project
m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.	Lessons 11, 12, 15,18, Student Case Study, Public Information Announcement, Service Learning Project

*has potential to meet the standard

Automotive Technology Pathway

Curriculum Application

Auto Technology curriculum includes units based on the following concepts:

- Natural resources are used to build and fuel the automotive industry.
- Petroleum products are formed from processing crude oil.
- Petroleum fractions (e.g., gasoline and oil) have chemical and physical properties.
- Oil has important uses in an internal combustion engine.
- Oil can be recycled.
- Man's use of petroleum products impacts the environment.
- Human have a responsibility to and for their environment.

The Earth Resources curriculum introduces and explains these ideas in an activity-based format.

Lesson Sequence in the Automotive Technology Pathway

Section 1

Lesson 1m Lesson Modification
As the World Turns: *The Earth's Resources*

Lesson 2 Meet Crude Oil: *An Earth Resource Case Study*

Lesson 2i Lesson Insert
Formation and Acquisition of Oil —A Brief Introduction

Lesson 5 Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

Section 2

Lesson 6 Slipping and Sliding with Oil: *The Lubricating Properties of Oil*

Lesson 7 Oil Goes to Work: *Lubricating Oil in the Engine*

Lesson 8 Oil, the Pickup Artist: *The Cleaning Function of Lubricating Oil*

Lesson 9 Oil's Coworkers: *Oil Additives*

Lesson 10 Oil Keeps Clean and Changes: *The Role of Oil Filters in the Engine*

Section 3

Lessons 11–13 Lessons Modification for Lessons 11, 12, and 13 to be taught as one lesson
What to Do with Used Oil? *Surface Water* (Lesson 11)
What to Do with Used Oil? *The Backyard* (Lesson 12)
What to Do with Used Oil? *The Trash Can* (Lesson 13)

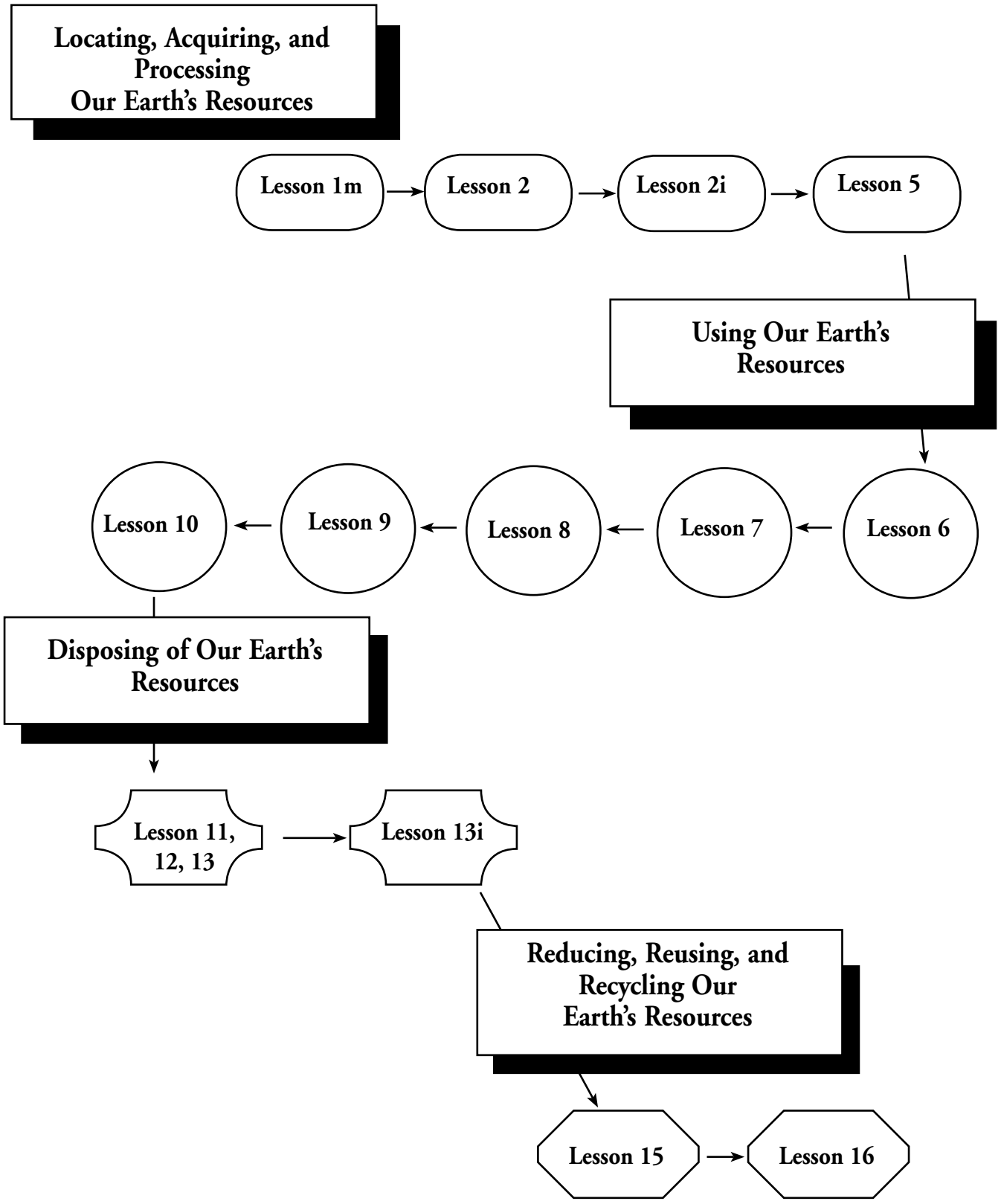
Lesson 13i Lesson Insert
Toxic Waste Disposal

Section 4

Lesson 15 What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

Lesson 16 Used Oil Learns the 3Rs: *Recycling, Re-Refining, Reusing*

Automotive Technology Pathway Schematic



Storyline Narrative

Automotive Technology Pathway

In the Automotive Technology Pathway students identify Earth resources used to manufacture items used to build or fuel an automobile. Students explore the positive and negative impacts of processing and using renewable and nonrenewable resources in the automobile industry.

This pathway follows the four major sections in the Earth's Resources curriculum:

- Section 1: Lessons 1, 2, 2i, and 5 focus on the formation, exploration, acquisition, and processing of crude oil.
- Section 2: Lessons 6–10 focus on use of oil by humans.
- Section 3: Lessons 11–13i focus on the environmental impact.
- Section 4: Lessons 15 and 16 focus on human responsibility toward the environment.

The focus of the Automotive Technology Pathway is the automotive industry's use of petroleum products—particularly oil. Thus, this pathway does not include an additional Student Case Study of another Earth resource. However, if time permits, encourage students to apply their understanding by assigning a Student Case Study (see page 63).

Section 1

Humans use natural resources to maintain and improve their existence. Just look at the automobile! It is built and fueled with products from our natural resources. In Lesson 1, **As the World Turns,** students identify commonly used items and try to identify the Earth resource from which they came. By modifying the lesson's prompts, students focus on the components of automobiles that can be made from these materials.

In Lesson 2, **Meet Crude Oil,** students explore how crude oil is formed over millions of years and determine that oil is a non-renewable resource. Lesson 2i, **Formation and Acquisition of Oil:** ***A Brief Introduction,*** provides students with an understanding that oil and gasoline, two very important materials in the automotive industry, come from crude oil.

Crude oil is distilled into its various components at refineries with each fraction processing individual chemical and physical properties. In Lesson 5, **Crude Oil Becomes Refined,** students use a model to understand how the process of fractional distillation is used in the refining of crude oil for human use.

Section 2

Once crude oil has gone through the distillation process, a variety of products are formed that can be used by humans. Among these products are lubricating oils that play a major role in automobiles in reducing friction

between moving objects. In Lesson 6, **Slipping and Sliding with Oil,** students explore the lubricating properties of oil and explore how oil prevents rust on metal parts of an engine.
Lesson 7, **Oil Goes To Work,** extends the student's understanding of how properties (i.e., lubrication) of a substance can determine its value for humans. The smooth operation of a car engine is paramount to the automotive industry. In this lesson, students understand how an Earth resource (oil) is used in a specific manner—that of keeping an engine running smoothly. In Lesson 8, **Oil, the Pickup Artist,** students observe the cleaning properties of lubricating oil and how oil affects an engine's performance and efficiency.

When oil is used, it undergoes physical and chemical changes. Some of these changes can be enhanced or negated by adding other substances. Lesson 9, **Oil's Coworkers:** ***Oil Additives,*** demonstrates the importance of foam inhibitors, anti-corrosives, and other additives in oil.

By-products of gasoline combustion contaminate the oil, even if additives are present. The purpose of the oil filter is to remove these by-products. In Lesson 10, **Oil Keeps Clean and Changes:** ***the Role of Oil Filters in the Engine,*** students understand how mixtures can be separated by filtering for particle size.

Section 3

Unfortunately, oil eventually becomes too dirty to be cleaned with the oil filter and it must be changed regularly to maintain the engine's efficiency. Disposal of the oil impacts the environment. In a series of lessons, students investigate this impact. For the Automotive Technology Pathway, students investigate the impact on surface water in Lesson 11, **What to Do with Used Oil?** ***Surface Water,*** and view demonstrations from Lesson 12, **What to Do with Used Oil?** ***The Backyard,*** and Lesson 13, **What to Do with Used Oil?** ***The Trash Can,*** to understand how the disposal of oil in these arenas impacts the environment.

In Lesson 13i, **Toxic Waste Disposal,** students extend their understanding of how substances can impact the environment. In this lesson, the students think of types of toxic wastes other than oil that might be generated from auto shops and discuss the impact of these wastes on the environment.

As an introduction to human responsibility, students conduct the home study from Lesson 11 and investigate how easy it is to recycle oil and dispose of toxic wastes. The students use information from the home study to do Lesson 15.

Section 4

In Lesson 15, **What Difference Can I Make?** students explore the recycling of used oil and other household hazardous waste. The storyline comes full circle with Lesson 16, **Used Oil Learns the 3Rs:** ***Recycling, Re-Refining, Reusing,*** where students examine the steps in the processing and re-refining of used oil, and discover that re-refined oil is a viable alternative to virgin oil.

Lesson Modification
Lesson 1
As the World Turns: The Earth's Resources

• Prethink

Replace the first portion of the Prethink section of Lesson 1 with these directions:

Record student responses for later review in Action Processing.

Let's brainstorm some materials found on or in the Earth.
Dirt, rocks, trees, and plants are some examples that students may list.

What components of automobiles can be made from these materials?
Students may mention that wood comes from trees; iron, steel, aluminum, and glass comes from the Earth, and other similar examples.

When do Earth materials become resources for humans to make automobiles or to use in automobiles?
Have students discuss this question in groups and present their ideas. Earth materials become resources when they are discovered to be useful to improve human existence and when processed to meet the needs of the industry.

Display samples of plastic, steel, aluminum, and glass.

At some point in time, humans identified that some materials found in or on the Earth could be used to create or fuel automobiles, making travel easier for man. In your group, brainstorm what Earth resources were used to make these objects.
Responses will vary, but should include, for example, that bauxite is used to make aluminum and steel is a refined iron product.

Be sure to review the concept, "What is an Earth resource?"

Continue with the Prethink as written in Lesson 1.

• Student Action

Replace the first prompt of the Student Action with this prompt:

In your groups, think of objects in the automotive industry that are used regularly. On chart paper, categorize and chart at least two of these objects using the model we just completed for aluminum. Be prepared to share your ideas with the class in 20 minutes.

• Replace the prompt for Home Study with this prompt:
Direct student to choose up to five common objects related to the automotive industry.

Lesson Insert
Lesson 2i
Formation and Acquisition of Oil: A Brief Introduction

Lesson Concept

Oil and gasoline are petroleum products processed from crude oil.
Natural resources have observable physical and chemical properties that allow them to be used for specific purposes within our automobiles.
Economic and environmental issues related to the acquisition of Earth resources influence the price and availability of these resources for the auto industry.

Suggested Time
20 minutes

• Prethink

Where does the oil and gasoline we use in our cars come from?
Students should understand that oil and gasoline are petroleum products processed from crude oil trapped in the rocks. The oil has to be extracted and distilled to be used.

• Student Action/Action Processing

Use the Simulating Oil Extraction in Lesson 4 as a classroom demonstration.

What are some of the environmental impacts associated with oil extraction or oil distilling?
Energy is required to process the oil. Land and resources are necessary to build the distilling facilities. Oil spills are a constant danger to our environment.

What makes one gasoline a regular grade while another is "supreme"?
Students should understand that the chemical and physical properties of the two grades of gasoline differ. This can make the car perform differently.

Lesson Modification
(Lessons 11, 12, and 13)

By using Lessons 11–13 and the Lesson insert (13i) as one extended lesson, students understand that disposing of used oil (and other toxic wastes) in improper places (dumping it in water, burying it in the dirt, or using the trash can) negatively impacts the environment.

To teach this series as one lesson, teach all of Lesson 11, use Lessons 12 and 13 as classroom demonstrations and finish with Lesson 13i (instructions following the modifications for Lessons 11, 12, and 13).
Be sure to set up the demonstrations ahead of time.

Make the following modifications to Lessons 11, 12, and 13.

Lesson 11: What to Do With Used Oil?: *Surface Water*
Teach as stated EXCEPT: introduce the Home Study after Lesson 13a (Toxic Waste)

Lesson 12: What to Do With Used Oil? *The Backyard*
• Prethink:
Use Prethink as written.

• Student Investigation
Use the Student Investigation as a demonstration.

Explain how the setup was done.

a. Ask two students to help with Part I of the demonstration. Have them do steps 5–7 and ask the class to record observations and results.
b. Ask two other students to do Part 2 and ask the class to record observations and results.

• Action Processing
Use the following prompts for Action Processing:

Using the Groundwater Diagram Overhead, ask another student to draw where the leaking oil would go based on the demonstration.

If the blue food coloring represented used motor oil, would you want to… drink the well water? Drink the lake water or eat the fish? Use the well water for irrigation?

Observe the data you obtained from the core samples. In which direction did the contamination move? Why did the contaminants move in that direction?

Lesson 13: What to Do With Used Oil? *The Trash Can*

• Prethink:

Use these prompts for the Prethink:

Let's look at another disposal method. Where does trash go after it leaves your house? *(landfill).* What might be some problems related to throwing oil in the trash that eventually ends up at the landfill?

• Student Investigation

Use the Student Investigation as a demonstration.

a. Display a Model Landfill Diagram and show the students the "Bottle Landfill." Ask students to compare the diagram and the model.
b. Ask several students to help with the demonstration (Student Investigation number 5–11). Have the class make observations over the three days.

• Action Processing

Use the following prompts for Action Processing:

Predict what will happen to your landfill after four days, after two weeks and after one month.

What happens to rainwater that falls on the landfill? What happens if the liner of a landfill fails? What happens if an animal eats materials that came into contact with the leachate?

Lesson Insert
Lesson 13i
Toxic Waste Disposal

Lesson Concept

A change in one part of the ecosystem has consequences for other parts of the ecosystem.
Disposal of toxic chemicals in landfills creates a severe environmental impact for the ecosystem.

Suggested Time
20 minutes

• Prethink:

What types of toxic waste might be generated from auto shops other than used oil?
Students should realize paints, thinners, and other solutions are biohazardous materials.

• Student Action/Action Processing

Based on your understanding of the impact of oil on the environment, what are some of the environmental impacts associated with other chemicals leaching into surrounding soils?
Chemicals entering ground waters, rivers, etc. eventually move into food chains, impacting a variety of living things.

What types of precautions would you implement if you were in charge of keeping landfills safe for the environment?
Students might suggest sealing landfills or containers that contain chemicals so that the chemicals could not contaminate the environment.

Summarize Lessons 11, 12, 13, and 13i by reminding students that dumping oil or other toxic wastes from automobiles anywhere causes a negative impact on the environment.

• Assign Home Study

Use the directions for Home Study, "How Easy Is It to Recycle Oil?" from Lesson 11 on page 282. Extend the question to: "How easy is it to dispose of toxic wastes from the automotive industry?"

Automotive Technology Pathway
Standards Alignment

Lessons 1m, 2, 2i 5, 6, 7, 8, 9, 10, 11 (12, 13, 13i), 15, 16

Physics

Heat and Thermodynamics	**Lesson Examples**
3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:	Lesson 8
g. * Students know how to solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.	Lesson 7

Chemistry

Chemical Bonds	**Lesson Examples**
2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:	
b. Students know chemical bonds between atoms in molecules such as H2, CH4, NH3, H2CCH2, N2, Cl2, and many large biological molecules are covalent.	Lesson 5
Solutions	**Lesson Examples**
6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:	Lessons 8, 10
a. Students know the definitions of solute and solvent.	Lessons 8, 10
c. Students know temperature, pressure, and surface area affect the dissolving process.	Lesson 5
d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	Lesson 11
Chemical Thermodynamics	**Lesson Examples**
7. Energy is exchanged or transformed in all chemical and physical changes of matter. As a basis for understanding this concept:	
b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.	Lesson 8

Biology/Life Sciences

Ecology	**Lesson Examples**
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:	Lessons 2, 11, 12, 13
a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.	Lessons 2, 11, 12, 13
b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.	Lessons 2, 4, 11, 12, 13, 15
d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.	Lessons 12, 13
e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.	Lessons 11, 12

* has potential to meet the standard

Earth Sciences

Earth's Place in the Universe	Lesson Examples
1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:	
c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.	Lesson 2
Dynamic Earth Processes	**Lesson Examples**
3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:	Lesson 2
a. Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.	Lesson 2
Biogeochemical Cycles	**Lesson Examples**
7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept:	
b. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.	Lesson 2
c. Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.	Lesson 2
California Geology	**Lesson Examples**
9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:	
a. Students know the resources of major economic importance in California and their relation to California's geology.	Lessons 1, 2, 5
c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.	Lessons 11, 12

Investigation and Experimentation

Investigation and Experimentation	Lesson Examples
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:	
a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.	Lessons 1, 5, 6, 8, 10, 11, 12, 13, 16
d. Formulate explanations by using logic and evidence.	Lessons 5, 6, 8, 9, 10, 11, 12, 13, 15, 16
g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.	Lessons 2, 9, 10, 11, 12, 13
i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).	Lessons 1, 2, 11, 12, 13
j. Recognize the issues of statistical variability and the need for controlled tests.	Lesson 8
k. Recognize the cumulative nature of scientific evidence.	Lessons 11, 12, 13, 15
l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.	Lessons 1, 2, 5, 7, 8, 11, 12, 13, 15, 16
m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.	Lessons 11, 12, 13, 15, 16

Pebbles in the Pathways

Earth Resources—A Case Study: Oil is designed around four ideas that students explore and investigate in order to understand oil as an Earth resource. These major ideas are: the formation, exploration, and acquisition of a natural resource (oil); the processing of the resource; its use by humans; and the collection of the resource for recycling.

The arrangement of the California Science Content Standards for grades 7 and 8, and high school chemistry, limits the creation of "pathways" which would address all four ideas. Yet, several Earth Resources lessons address content standards at these grades. These lessons have been identified as "pebbles" that will engage students in "real-life" exploration of science.

Use these "pebbles" (lessons) as they best fit into your own lesson plans to create meaningful learning sequences for students.

Pebbles in the Pathway Grade 7

Earth and Life History (Earth Science)	**Lesson Examples**
4. Evidence from rocks allows us to understand the evolution of life on Earth. As the basis for understanding this concept:	
a. Students know Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.	Lessons 2, 3
b. Students know the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impact of an asteroid.	Lesson 2
d. Students know evidence from geologic layers and radioactive dating indicate the Earth is approximately 4.6 billion years old, and that life has existed for more than 3 billion years.	Lesson 2
e. Students know fossils provide evidence of how life and environmental conditions have changed.	Lessons 2, 3
f. Students know how movements of the Earth's continental and oceanic plates through time, with associated changes in climate and geographical connections, have affected the past and present distribution of organisms.	
g. Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale.	Lessons 2, 3
Investigation and Experimentation	**Lesson Examples**
7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:	
a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.	Lessons 1, 5, 8, 10, 11, 12, 13, 17, Student Case Study
b. Usetilize a variety of print and electronic resources (including the World Wide Web) to collect information as evidence as part of a research project.	Lessons 1, 2, 7, 15, Student Case Study, Service Learning Project
c. Communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.	Lessons 5, 8, 10, Student Case Study, Service Learning Project
d. Construct scale models (simulations)*, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).	Lessons 4, 10, 11, 12, 13, 14, Student Case Study
e. Communicate the steps and results from an investigation in written reports and verbal presentations.	All Lessons, Student Case Study, Service Learning Project

* has potential to meet the standard

Pebbles in the Pathway Grade 8

Reactions	**Lesson Examples**
5. Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept:	
c. Students know reactions usually liberate heat or absorb heat.	Lesson 8
d. Students know physical processes include freezing and boiling, in which a material changes form with no chemical reaction.	Lessons 5, 8, 9, 10, 16
Chemistry of Living Systems (Life Science)	**Lesson Examples**
6. Principles of chemistry underlie the functioning of biological systems. As a basis for understanding this concept:	
a. Students know that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms.	Lesson 2
b. Students know that living organisms are made of molecules largely consisting of carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur.	Lesson 2
Investigation and Experimentation	**Lesson Examples**
9. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:	
a. Plan and conduct a scientific investigation to test a hypothesis.	Lessons 4, 5, 6, 8, 10, 11, 12, 13, 17, Student Case Study*
b. Evaluate the accuracy and reproducibility of data.	Student Case Study,* Service Learning Project*
c. Distinguish between variable and controlled parameters in a test.	Lessons 5, 8, Student Case Study,* Service Learning Project*
e. Construct appropriate graphs from data and develop quantitative statements about the relationships between variables.	All lessons that ask students to display their data,* Student Case Study,* Service Learning Project*
f. Apply simple mathematical relationships to determine one quantity given the other two (including speed = distance/time, density = mass/volume, force = pressure x area, volume = area x height).	Lessons 11, 14
g. Distinguish between linear and non-linear relationships on a graph of data.	Student Case Study,* Service Learning Project*

*has potential to meet the standard

Pebbles in the Pathway High School Chemistry

Solutions	**Lesson Examples**
6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:	Lessons 8, 10
a. Students know the definitions of solute and solvent.	Lessons 8, 10
c. Students know temperature, pressure, and surface area affect the dissolving process.	Lesson 5
d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	Lesson 11
Chemical Thermodynamics	**Lesson Examples**
7. Energy is exchanged or transformed in all chemical and physical changes of matter. As a basis for understanding this concept:	
b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.	Lesson 8